



EUROPEAN PATENT APPLICATION

(43) Date of publication:
09.11.2005 Bulletin 2005/45

(51) Int. Cl. 7: H04L 12/28, H04Q 7/36

(21) Application number: 04291152.9

(22) Date of filing: 04.05.2004

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IT LI LU MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL HR LT LV MK

(72) Inventor: Gerlach, Christian Georg
71254 Ditzingen (DE)

(74) Representative: Rausch, Gabriele et al
Alcatel
Intellectual Property Department, Stuttgart
70430 Stuttgart (DE)

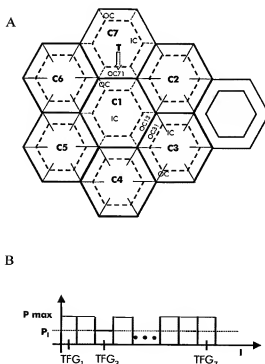
(71) Applicant: ALCATEL
75008 Paris (FR)

(54) **Method for inter-cell interference coordination with power planning for OFDM mobile communication system**

(57) A method for inter-cell interference coordination with power planning in a radio communication system employing multi-carrier techniques such as OFDM for the air interface communication between a network (N) and a plurality of user terminals (T1 to Tn), the network (N) comprising a plurality of base stations (NE1 to NE7) having means for communication with the user terminals (T1 to Tn) located inside their cell service area

(C1 to C7), the cells arranged following an adjacent cell pattern, where neighbor cells do not have the same number and cells with the same number are separated by at least one cell in-between, for resource planning purposes, each cell having an inner cell region (IC) and a border cell region (OC) in which inter-cell interference is affecting the quality of service received by a user terminal (T).

Figure 4



Description

[0001] The present invention relates to wireless communications systems, and more particularly, to a method for minimizing inter-cell interference in digital radio cellular communication systems employing multi-carrier transmission techniques, such as orthogonal frequency division multiplexing (OFDM).

[0002] Communication systems employing many sub-carriers, such as those that employ OFDM technology are currently used for the transmission of high-speed digital radio and television signals, e.g. Digital Audio Broadcasting (DAB) and Digital Video Broadcasting Terrestrial transmission mode (DVB-T) systems. Also, OFDM has become a widely accepted standard high bit rate transmission technique for the realization of wide-band air interfaces for wireless access to current local area networks (LAN), e.g. HiperLAN and IEEE WLAN systems. And, in the same way, the 3rd Generation Partnership Project (3GPP), for the standardization of high-speed broadband wireless mobile communication systems, is recently considering the application of OFDM techniques for the high speed data packet access (HSDPA) air interface communication between the radio access network (RAN) and the user equipment (UE).

[0003] Since OFDM is a multi-carrier transmission technique, the available spectrum is divided into many sub-carriers, each being modulated by data at a relatively low data rate. OFDM supports multiple access by allocating different sub-carriers to different users. The sub-carriers for OFDM are orthogonal and closely spaced to provide an efficient spectrum usage. Each narrow band sub-carrier is modulated using various modulation formats, such as quadrature phase-shift keying (QPSK) and quadrature amplitude modulation (QAM).

[0004] Due to the increasing popularity of high-speed broadband wireless mobile communication, of particular interest are wireless communication systems comprising bandwidth-efficient multiple access schemes. Wireless systems are shared media systems, that is, there is a fixed available bandwidth that must be shared among all the users of the system, so it is desired that radio access systems be as efficient as possible to maximize the number of users that can be served and the data rates at which the service is provided.

[0005] Typical radio access networks are implemented as so-called "cellular" systems which comprise a plurality of base stations controlled by a radio network controller (RNC), the base stations communicating with a plurality of user mobile terminals which are located inside their cell service area. It is also well known in the art that such cellular wireless system may present particular intra- and/or inter-cell interference problems which limit the capacity of the system, the intra-cell interference being the interference experienced by one user that is caused by other users communicating within

the same cell, and the inter-cell interference defined as the interference experienced by one user that is caused by other users communicating in cells other than the one in which the user is located.

[0006] In prior art narrow band time division multiple access (TDMA) systems, such as group special mobile (GSM), neighboring base stations use different, non-overlapping parts of the available bandwidth. However, base stations that are sufficiently far away from each other to avoid substantial interference between them, i.e., non-neighboring base stations, may use the same parts of the available bandwidth. Notwithstanding such frequency "re-use", the bandwidth available for use in each cell is a small part of the total available spectrum. As a result, the system has a low "spectral" efficiency.

[0007] In prior art code division multiple access (CDMA) systems, although the entire bandwidth is used by each base station which means a frequency "re-use of one", the downlink communication in each base station cell suffers from a small number of other neighbor high-power base stations, thus limiting the capacity of the access system. This becomes particularly serious at the boundary region of a cell where the transmitting base station and an interfering base station are equidistant from the intended user. This situation is relieved by "soft handover", where two or more base stations transmit to the user simultaneously. This soft handover mechanism though is not available for the recently standardized HSDPA service using a fast automatic repeat request (ARQ) mechanism, since ARQ is efficient only if just one base station is involved.

[0008] For OFDM, as in the CDMA case, we also consider a network deployment based on a frequency re-use scheme of one, that is, all frequencies or OFDM subcarriers, in the 5MHz channel bandwidth, are used in every cell. In such a frequency re-use of one cellular network, the adjacent base stations also generate strong interference particularly for users at the edge of the cell coverage. Therefore, depending on the traffic loading of the surrounding cells, a basic frequency "re-use-one" OFDM network deployment may result, similar to the CDMA case, in a relatively poor quality of service and potentially low data rates for users at the cell edges.

[0009] To improve the distribution of data rate across the entire cell in OFDM access systems and to evenly distribute the interference to all users, particularly for cell edge users, some inter-cell interference mitigation techniques have been proposed. In document "Benefits of Frequency Hopping for the OFDM DL", 3GPP TSG-RAN 1 Meeting #32, R1-030523, Marne La Vallée, France, 19-23 May 2003, a solution is proposed in which the main idea is to interleave differently the transmitted subcarriers in each OFDM symbol over some or all of the channel bandwidth, prior to transmission. This variable frequency interleaving is done by simply assigning each cell (or sector) a unique hopping sequence, i.e., a distinct frequency interleaver sequence. Thus, in the case of partial frequency loading the interference is mit-

igated. The neighboring cells can use different frequency groups to avoid inter-cell interference. Another solution proposed to reduce inter-cell interference is described in document "Revised text proposal for OFDM Traffic Multiplexing Solutions", 3GPP TSG RAN1 #34, R1-030970, Seoul, Korea, 6-10 October, 2003, which is based on special time frequency mapping patterns that simultaneously achieve large diversity gains and small cross-interference in the case of asynchronous interfering transmissions and partial frequency load.

[0010] It is the object of the invention to provide a new method for inter-cell interference coordination using power planning in order to improve the quality of service particularly for users receiving service at cell border in a mobile communication system using OFDM transmission technology.

[0011] The object is achieved, according to the invention, by a method for inter-cell interference coordination with power planning according to claim 1. It is also achieved by a mobile radio network according to claim 10, a network element according to claim 11, and a user terminal according to claim 12.

[0012] Advantageous configurations of the invention emerge from the dependent claims, the following description and the drawings. For example, it is seen advantageous that, by using the proposed invention, a more efficient use of the radio resources is done, specially for terminals located in the cell border region. Also advantageous is that the frequency usage in the inner circle area of the cell is unaffected. The invention further improves both the quality of service experienced by the user and the coverage of the base station service across the entire cell area. By using the proposed invention, the cell traffic throughput can be increased. Another advantage is that, fast automated repeat request (ARQ) mechanisms can be used for the full coverage area of the cell, i.e. also for terminals at the cell border.

[0013] An embodiment example of the invention is now explained with the aid of Figures 1 to 5.

Fig. 1 shows an example of conventional subcarrier mapping to user channels into an OFDM time-frequency grid.

Fig. 2 illustrates a block diagram of a conventional OFDM mobile communications system including the network and the user terminals.

Fig. 3 A, B, C shows exemplary partitionings of the OFDM time-frequency grid in time-frequency groups according to the invention

Fig. 4 A, B shows a method for inter-cell interference coordination using power planning according to the invention.

Fig. 5 illustrates the resource usage for terminals in the border region in a hexagonal cell pattern when

the method for inter-cell coordination with power planning according to the invention is applied.

[0014] Figure 1 shows an exemplary allocation of sub-carriers S1 to SN to four user channels A, B, C and D in the OFDM time-frequency (T-F) grid.

[0015] OFDM offers the possibility to flexibly allocate one or more subcarriers S1 to SN to one user or one logical channel A, B, C or D to control the data rate for this user channel. Since this can change also over time in a TDMA system (e.g. with a change period of K symbol periods Ts e.g. a period of 2ms), we have a 2-dimensional resource allocation grid, hereinafter referred as T-F grid, as indicated in Figure 1.

[0016] Some of the time-frequency grid locations may not be available for data transmission, because they are used for carrying pilot or signaling information. User assignment of remaining locations can be done based on frequency or time or a combination of both.

[0017] Figure 2 shows a block diagram of a mobile communications system in which a mobile radio network N, including a plurality of network elements NE1 to NEN, and a plurality of user terminals T1 to Tn exchange data information via an air interface downlink channel DC and an uplink channel UC using multi-carrier modulation schemes, at least in the downlink, such as OFDM. The network elements NE1 to NEN can be for example base stations, radio network controllers, core network switches, or any other communication elements which are generally used for wireless mobile communications.

[0018] Figure 3 A, B, C shows two exemplary partitionings of the OFDM T-F grid in a number S of disjoint "subsets", hereinafter referred as "T-F groups" TFG1 to TFGS.

[0019] According to the invention, the OFDM T-F grid is partitioned in a number of orthogonal, non-overlapping T-F patterns, as shown in figures 3A and 3B, and said T-F patterns are grouped in a number S of disjoint subsets or T-F groups TFG1 to TFG S, i.e., each T-F group TFG1 to TFGS comprising at least one T-F pattern, as shown in figure 3C. The partitioning of the OFDM T-F grid can be done by the mobile network N or can be introduced and configured by an operator in the mobile network N previous to communication.

[0020] Figure 3A shows one out of 15 possible T-F patterns in which the OFDM T-F grid can be partitioned, consisting of 15 different sub-carrier frequency sub-bands FS1 to FS15, each sub-band having 40 sub-carriers, and in which the frequency sub-bands are changed over the time. One or more of such T-F patterns can be grouped then to form a T-F group.

[0021] Figure 3B shows two out of 16 possible T-F patterns FP1 to FP16 in which the OFDM T-F grid can be partitioned, said T-F patterns allocating the same sub-carriers over the time T. Because of the constant allocation of the same sub-carriers over the time these T-F patterns will be hereinafter referred just as "frequency patterns".

[0022] The partitioning of the OFDM T-F grid so that the OFDM communication channel is designed in a way that at least two pilot channels can be received in parallel according to the invention will be hereinafter described by way of an example solution. For example, an OFDM system employing 704 sub-carriers, not considering the direct current(DC)-carrier, in a 5 MHz band and a number $K=12$ of OFDM symbols in a period T_s of 2 ms is looked at.

[0023] The pilot and signaling information can be placed every 12th sub-carrier such as on the numbers 0, 12, 24, 36, 48, 60, 72 etc. up to 696. So, for example, every even OFDM symbol the sub-carriers 0, 24, 48, 72 etc. carry pilot information and the others 12, 36, 60, etc. signaling information while every odd OFDM symbol the sub-carriers 12, 36, 60, etc. carry pilot information and the others 0, 24, 48, etc. the signaling. In a neighboring cell, e.g. cell two C2, the pilot/signaling sub-carriers are shifted by one in the frequency direction such as 1, 13, 25, 37, 49, 61, 73, etc. up to 697. This configuration allows 12 shifts until the original locations are reached again. Thus 12 different interleaving non-overlapping pilot/signaling patterns are possible and can be distributed in an area so that neighboring cells never use the same pilot/signaling sub-carriers.

[0024] Since $16 \times 44 = 704$ then 16 frequency patterns FP1 to FP16 can be defined consisting of 44 sub-carriers each. The 44 sub-carriers can be placed, for example, in 11 frequency strips FPN1 to FPN11 spread across the frequency axis while each strip FPNn contains 4 adjacent sub-carriers as indicated in Figure 5. The distance between strips FPNn of the same frequency pattern FPN is then $16 \times 4 = 64$ sub-carriers, so, for example, the first frequency pattern FP1 contains the sub-carriers 0 to 3 allocated in its first frequency strip FP1S1, 64 to 67 allocated in its second frequency strip FP1S2, 128 to 131 in the third frequency strip FP1S3, etc. According to the partition explained above, then each frequency pattern FP1 to FP16 contains at most 4 pilot or signaling sub-carriers in all its locations independent of the shift of the pilot pattern. So for data transmission there are always 40 of the 44 sub-carriers remaining in 12 OFDM symbols giving a total rate per each 2 ms block of $12 \times 40 = 480$ complex sub-carrier symbols (480 QAM symbols) usable for data transmission.

[0025] Each basic frequency pattern (FP1 to FP16) occupies the same locations in all cells independent of the cell specific pilot pattern and further contains sufficient place in each pattern to accommodate for the specific sending cell pilot positions leaving at least always the basic number of time-frequency locations for the basic channel data rate of 480 complex sub-carrier symbols of such a pattern, so a basic Frequency pattern gets no interference from the sending cell pilots and just interference from neighboring cells with different pilot pattern and only maximally as much as amounts to the overhead place of 4 sub-carriers \times 12 OFDM symbols

left for sending pilot locations i.e. the difference between the total place of the Frequency pattern (44x12) and the basic number of time-frequency locations (40x12) for the basic channel data rate.

[0026] Figure 3C is a simplified diagram showing the T-F groups TFG1 to TFGS arranged just in one dimension over a horizontal axis according to the T-F group indices I, and the vertical axis being the power P of transmission. For the sake of simplicity of representation of the figures, but without loss of detail as explained in figures 3A and 3B, the T-F groups are hereinafter depicted as blocks.

[0027] As already mentioned above, one or more T-F patterns can be assigned to a T-F group, for example, relating to figure 3B, the frequency patterns one FP1, three FP3 and ten FP10 could be assigned to a T-F group one TFG1, the frequency patterns two FP2, six FP6, seven FP7 and twelve FP12 could be assigned to a T-F group two TFG2, and the rest of frequency patterns available FP4, FP5, FP8, FP9, FP11, FP13, FP14, FP15, FP16 could be assigned to a T-F group three TFG3. There are then three S=3 disjoint subsets or T-F groups TFG1 to TFG3, and one or more T-F patterns from said T-F groups TFG1 to TFG3 can be later assigned to a user terminal T for communication with the mobile radio network N.

[0028] Figure 4 A, B illustrates a method for inter-cell interference coordination according to the invention. In Figure 4A, an example of a cell planning scenario is shown in case the OFDM T-F grid is divided in seven T-F groups TFG1 to TFG7 according to the invention, while Figure 4B shows an example of how power limitation is made in one of the cells C3 according to the invention.

[0029] As already mentioned above, the method comprises a resource planning procedure prior to communication in which the OFDM T-F grid or set of all T-F patterns is arranged in a number S of disjoint subsets named T-F groups.

The number of T-F subsets S can be, for example, seven $S=7$ or twelve $S=12$ to have some flexibility when the creation of new cells is needed in an area.

[0030] In Figure 4A it is shown an exemplary cell planning scenario according to the invention in case the OFDM T-F grid is divided in seven T-F subsets TFG1 to TFG7. Although not shown in the example of the figure, it is assumed that a base station is located at the center of each cell and it relays the information signals to and from user terminals located within the cell. Each cellular region is denoted by a hexagonal cell C1 to C7, each having an inner cell region IC, i.e., an area near the base station where the inter-cell interference has attenuated enough so that it does not limit the capacity of the access system, and a border cell region OC, in which inter-cell interference is affecting the quality of service received by the user. Each base station is assigned a different number C1 to C7 before the cell numbers repeat again further away, as known from classical cell planning. Now

a time-frequency group corresponding just to a cell undergoes special treatment according to the invention, i.e., it is emitted only with reduced power in that cell so that its power is smaller than a limit power value P_I , said limit power value P_I also being smaller than a maximum power P_{max} with which the other T-F groups can be emitted in that cell. Specifically, in the example of figure 4A, in cell one C1, T-F group one TFG1 is emitted with reduced power while in the cell C1 the other T-F groups TFG2 to TFG7 can be emitted with maximum power P_{max} ; in cell two C2, T-F group two TFG2 is power restricted while the other T-F groups TFG1 and TFG3 to TFG7 can be emitted with full power; and so on successively so that in cell seven C7 the T-F group seven TFG7 is emitted with reduced power and the other T-F groups TFG1 to TFG6 can be emitted with full power.

[0031] The cell pattern shown in figure 4A, in which a first cell C1 has six adjacent cells C2 to C7 may be repeated in order to cover a wider service area.

[0032] The invention is based on the fact that the resource situation in the inner circle of a cell IC is not much limited by the signal-to-interference ratio (SIR) but by the bandwidth, and outside the inner circle, particularly in the boundary region of a cell OC, the capacity is more limited by the inter-cell interference situation. According to the invention then, the power at which a base station cell Cn transmits information to the user terminal using a determined T-F group TFGn is limited to a determined power value P_I . This power value should be chosen with view to the situation at the cell border OC where the signal and interference is approximately equally attenuated. It should not be so high as to produce substantial inter-cell interference for a user terminal located in the border region OC of a neighbor cell using said T-F subset TFGn for communication with its origin base station. So it should guarantee an SIR to allow satisfying transmission. On the other hand, it should not be too low to also allow satisfying usage in the inner circle of the cell IC if possible.

[0033] This will be further explained in detail by way of the example of figure 4A. According to the invention the OFDM communication channel is designed so that terminals can receive at least two pilot channels in parallel. When the terminal T is served by, for example, a base station of cell seven C7 and moves from the inner circle IC to the cell border of said cell, in the direction of a neighbor cell, for example cell one OC71, it reports to the origin serving base station (of cell seven C7) which other base station is provoking the strongest interference, which in this case is the base station of cell one C1. The origin base station (of cell seven C7) then assigns the terminal T in that outer cell region OC71 one or more T-F patterns from T-F group one TFG1, which base station of cell one C1 is transmitting with reduced power, so that the signal-to-interference level experienced by the terminal T disturbed from base station of cell one C1 stays above a certain level and a useful transmission can be kept up.

[0034] Further, more generally, we could say that originating at a cell Cn, if a terminal approaches the border region OCni in direction to another cell, say Ci, it gets allocated one or more T-F patterns from the T-F group TFGi which in this other cell Ci is emitted with limited power. Prior to communication then, a network resource planning is made so that each base station is assigned a different frequency group TFG1 to TFG7, which they emit with limited power and each base station has knowledge of all the planned frequency groups TFG1 to TFG7 in order to transmitt information inside the inner circle of the cell IC and assign the terminals the suitable T-F group when it approaches the border region OC and reports the interference from a specific cell number. This procedure is done before handover takes place.

[0035] The principle could also be further enhanced regarding the cell corners (where three cells meet) if the T-F groups e.g. TFG1 are further split in subsets e.g. two subsets TFG1a and TFG1b with different power usage, above a limit power value P_I , dependent on the cell number.

[0036] With the proposed soft network planning all frequencies are unaffected in the inner circle. Restrictions by network planning only takes place in the border regions where the availability of the frequencies is only slightly, e.g. 6/7 or 6/12, reduced.

[0037] Figure 4B shows an example of how power emission is done in cell three C3 for each T-F group TFG1 to TFG7 according to the teachings of the invention. The T-F group three TFG3 is emitted with reduced power smaller than a limit power value P_I compared to a maximum emission power P_{max} that can be used for communication with the other T-F groups TFG1, TFG2 and TFG4 to TFG7 in that cell C3.

[0038] The ratio P_{max}/P_I should guarantee an SIR allowing satisfying transmission with T-F group three TFG3 when used by a terminal approaching from a neighboring cell, into the border region in direction to cell three OC13.

[0039] In order to average interference for user terminals in neighboring cells that are not using coordination in the inner cell region IC, in a preferred embodiment of the invention the time-frequency pattern or time-frequency group assignments to these terminals are periodically changed, e.g. every change period of a number K of OFDM symbols, in a random or pseudo random manner. This shapes the produced inter-cell interference more evenly over all time frequency patterns.

[0040] Further, an important advantage of the method for inter-cell interference coordination with power planning method according to the invention is that it allows the origin base station cell alone to schedule the packets for the terminal for the full coverage area of the cell. Since no other base station besides the origin base station is involved in the transmission of data packets to the terminal, this allows that efficient fast automated repeat request (ARQ) mechanisms such as hybrid automated repeat request (HARQ), which allows the receiv-

er to inform the transmitter that certain packets were either not received or corrupted, can be used for retransmission of said corrupted packets from the origin base station to the terminal.

[0041] Fig. 5 illustrates the resource usage for terminals in the border region in a hexagonal cell pattern with a cell repetition factor of seven, when the method for inter-cell coordination with power planning according to the invention is applied. If one assumes isotropic propagation in a plane area and marks the strips from the other cells also with the allocated frequency block numbers, one can see in Figure 5 that all frequencies 1 to 7 are evenly used over the area with full symmetry giving a full resource usage (for evenly distributed terminals). So an evenly resource usage is achieved with the method according to the invention.

[0042] This shows also that the availability of T-F pattern resources for this solution is already 6/7 in the border region of the cell which is quite high.

[0043] For the sake of generalization, it shall be understood, that although for the explanation of the present invention an OFDM modulation scheme has been used, the above proposals can in principle as well be adapted to any multi-carrier modulation scheme apart from OFDM.

[0044] Further, the invention is illustrated for a hexagonal cell situation with omnidirectional antennas but can be generalized also for other patterns, and also for sectors within a cell.

[0045] It shall also be understood that means to carry out the methods herein described can be located anywhere in the mobile radio network N, that is, in a network element NE such as a base station or a radio network controller or by means of a radio resource manager entity, inside or outside the network elements NE. Said means being implemented in hardware or software form.

Claims

1. Method for inter-cell interference coordination with power planning in a radio communication system employing multi-carrier techniques such as OFDM for the air interface communication between a network (N) and a plurality of user terminals (T1 to Tn), the network (N) comprising a plurality of base stations (NE1 to NE7) having means for communication with the user terminals (T1 to Tn) located inside their cell service area (C1 to C7), the cells arranged following an adjacent cell pattern, where neighbor cells do not have the same number and cells with the same number are separated by at least one cell in-between, for resource planning purposes, each cell having an inner cell region (IC) and a border cell region (OC) in which inter-cell interference is affecting the quality of service received by a user terminal (T).

characterized in that

- an OFDM wireless communication channel is designed so that a terminal (T) can receive at least two pilot channels in parallel, one for each cell service area interfering at the border cell region (OC),
 - an OFDM time-frequency grid is partitioned in a number of orthogonal, non-overlapping time-frequency patterns, and said time-frequency patterns are grouped in a number (S) of disjoint subsets or time-frequency groups (TFG 1 to TFG7), the number (S) of disjoint subsets corresponding to the number of different cells from the cell pattern for resource planning,
 - in each cell (C1 to C7) all time-frequency groups (TFG1 to TFG7) are used for communication with the terminals, but emission within a determined time-frequency group (TFG3) corresponding to the cell number (C3) is done with reduced power limited to a certain power value (PI) which is smaller than a maximum power (Pmax) available for transmission within the time-frequency groups,
 - when a terminal (T) moves from an inner cell region (IC) of a serving cell (C7) to the border cell region of said cell (OC71) and in the direction of a neighbor cell (C1), it measures pilot signals from the interfering neighbor cells (C1) in that region (OC71) and reports to the mobile radio network (N) information about the strength of reception from these cell pilot signals,
 - based on the terminal (T) information an network criteria, the mobile radio network (N) assigns to the terminal (T) time-frequency patterns of the time-frequency group (TFG1) with which said neighbor cell (C1) emits with limited power.
2. The method for inter-cell interference coordination with power planning of claim 1 characterized in that the ratio between the maximum power (Pmax) available for transmission with the time-frequency groups (TFG2 to TFG7) and the limited power value (PI) for transmission within a determined time-frequency group (TFG1) in a cell (C1) guarantees an SIR allowing satisfying transmission with said power restricted time-frequency group (TFG1) when used by a terminal (T) originating from a cell (C7), and moving into the border region in direction of a neighboring cell (OC71).
 3. The method for inter-cell interference coordination with power planning of claim 1 characterized in that the time-frequency groups (TFG1) are further split in disjoint subsets e.g. two subsets (TFG1a and TFG1b), with different power limit above the

limit power value (PI) used for power restriction of time frequency groups, dependent on the cell number (C1), so as to deal with the interference at the cell corners of three cells.

4. The method for inter-cell interference coordination with power planning of claim 1 **characterized in that** the mobile radio network (N) further uses an ARQ mechanism with the terminal (T), such as HARQ, to reschedule packets that were received in error when sent to the terminal (T).
5. The method for inter-cell interference coordination with power planning of claim 1 **characterized in that** the time-frequency pattern or time-frequency group assignments for the terminals (T) in the inner cell region (IC) not using coordination are periodically changed in a random or pseudo random manner, so as to shape a caused inter-cell interference more evenly over the time-frequency pattern.
6. The method for coordinated interference avoidance of claim 1 **characterized in that** the base stations (NE1 to NE7) are not time synchronized.
7. The method for inter-cell interference coordination with power planning of claim 1 **characterized in that** the OFDM time-frequency grid is partitioned in a number of orthogonal, non-overlapping frequency patterns (FP1 to FP16) that use no frequency hopping.
8. The method for inter-cell interference coordination with power planning of claim 7 **characterized in that** the OFDM system pilot channels received by the terminal (T) in different cells are designed in an interleaving non overlapping fashion with pilot symbols having higher energy as the data.
9. The method of claim 7 **characterized in that** each basic frequency pattern (FP1 to FP16) occupies the same locations in all cells independent of the cell specific pilot pattern and further contains sufficient place in each pattern to accommodate for the specific sending cell pilot positions leaving at least always the basic number of time-frequency locations for the basic channel data rate of such a pattern, so that a basic frequency pattern gets no interference from the sending cell pilots and just interference from neighboring cells with different pilot pattern and only maximally as much as amounts to the overhead place left for sending pilot locations i.e. the difference between the total place of the frequency pattern and the basic number of time-frequency locations for the basic channel data rate.
10. A mobile radio network (N) **characterized in that** it comprises means for partitioning an OFDM time-

frequency grid in a number of orthogonal, non-overlapping time-frequency patterns, and grouping them in a number (S) of disjunct subsets or time-frequency groups (TFG1 to TFGS), where a time-frequency group contains at least one of said time-frequency patterns, and assigning a user terminal (T) one or more of said time-frequency patterns for communication; means for transmitting inside a cell using all time-frequency groups (TFG1 to TFGS) and for limiting the power of emission for one of said groups in each cell; means for receiving signaling information from a terminal (T) about strength of reception measurements on cell pilot signals in a border cell region (OC71) and means for analyzing said information and for assigning to the terminal (T) a time-frequency group (TFG1) with which an interfering cell (C1) emits with reduced power limited by a certain power value (PI).

11. A network element (NE) **characterized in that** it comprises means for receiving information about a determined cell pattern (C1 to C7) and/or OFDM time-frequency grid arrangement in a number (S) of disjunct subsets or time-frequency groups (TFG1 to TFGS), where a time-frequency group contains at least one time-frequency pattern; means for assigning a user terminal (T) one or more of said time-frequency patterns for communication; means for transmitting inside a cell using all time-frequency groups (TFG1 to TFG7) and for limiting the power of emission for one of said groups in each cell; means for receiving signaling information from a terminal (T) about strength of reception measurements on cell pilot signals in a border cell region (OC71) and means for analyzing said information and for assigning to the terminal (T) a time-frequency group (TFG1) with which an interfering cell (C1) emits with reduced power limited by a certain power value (PI).
12. A user terminal (T) **characterized in that** it comprises means for receiving at least two OFDM pilot channels in parallel, means for negotiating one or more time frequency patterns from time-frequency groups (TFG1 to TFG7) with a mobile radio network (N) communication; means for measuring the OFDM pilot signals from interfering neighbor cells in a border cell region (OC71) and for reporting said information to the mobile radio network (N).

Figure 1

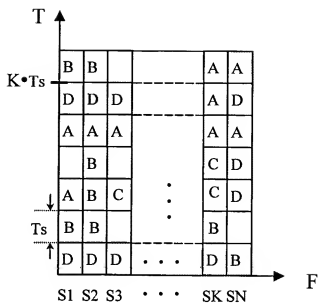


Figure 2

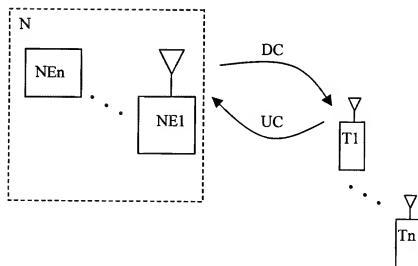


Figure 3

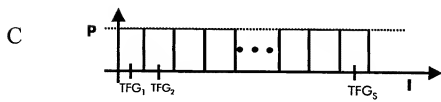
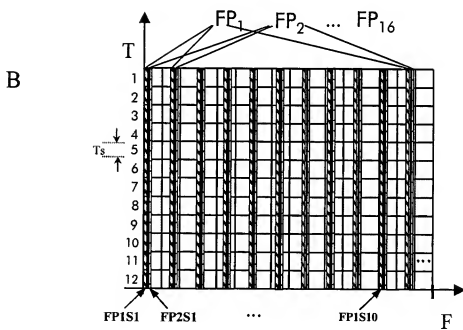
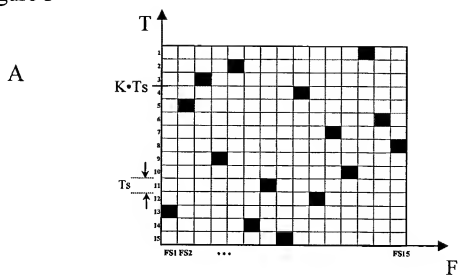
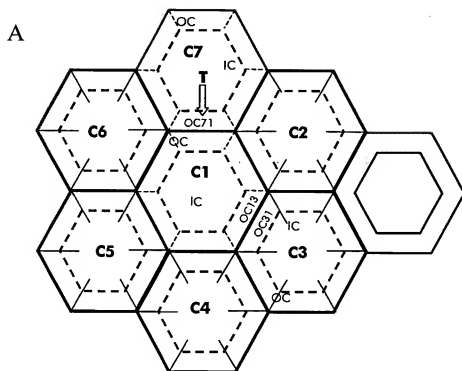


Figure 4



B

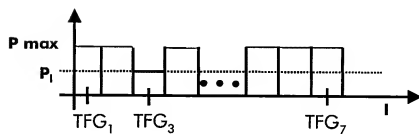
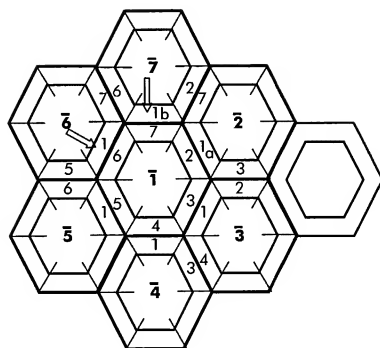


Figure 5



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 29 1152

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	WO 2004/019538 A (LANE FRANK A ; LAROIA RAJIV (US); LI JUNYI (US); FLARION TECHNOLOGIES) 4 March 2004 (2004-03-04) * abstract * * page 1, line 6 - line 13 * * page 3, line 5 - line 12 * * page 5, line 16 - line 17 * * page 6, line 29 - page 8, line 2 * * page 9, line 12 - line 24 * * page 15, line 23 - line 29 * * page 28, line 10 - line 19 * * page 35, line 15 - page 37, line 5 * * page 40, line 3 - line 5 * * figures 1,3,9-12 * -----	1-12	H04L12/28 H04Q7/36
X	WO 98/44754 A (NOKIA TELECOMMUNICATIONS OY ; RINNE MIKKO (FI); RINNE MIKA (FI); SALON) 8 October 1998 (1998-10-08) * abstract * * page 2, line 5 - line 11 * * page 3, line 17 - page 4, line 4 * * page 7, line 22 - page 12, line 17 * * figures 3,4,7-9C * -----	1-12	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H04Q H04B
A	WO 95/17048 A (SILBERSCHATZ GIORA ; MILLER SHMUEL (IL); RITZ MORDECHAI (IL); GEOTEK IN) 22 June 1995 (1995-06-22) * the whole document * ----- -/--	1-12	
The present search report has been drawn up for all claims			
Place of search Berlin		Date of completion of the search 1 October 2004	Examiner Alonso Maleta, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

1

BPO FORM 1500 (01.02.2004)



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 29 1152

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	US 2003/123425 A1 (HOLTZMAN JACK ET AL) 3 July 2003 (2003-07-03) * paragraphs [0016] - [0022], [0028] * * paragraphs [0051], [0061] - [0064] * * paragraphs [0092] - [0096], [0101] - [0109] * * paragraphs [0128] - [0132] * * paragraphs [0175] - [0184] * * paragraphs [0194] - [0197] * * paragraphs [0263] - [0277] * * paragraphs [0360] - [0365] * -----	1-12	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
The present search report has been drawn up for all claims			
Place of search Berlin		Date of completion of the search 1 October 2004	Examiner Alonso Maleta, J
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

1
EPO FORM 1503, 03.02.2004 (P/C/D)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 04 29 1152

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

01-10-2004

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 2004019538	A	04-03-2004	US 2004095904 A1	20-05-2004
			WO 2004019529 A2	04-03-2004
			WO 2004019537 A2	04-03-2004
			WO 2004019538 A2	04-03-2004
			US 2004095880 A1	20-05-2004
			US 2004095902 A1	20-05-2004
			US 2004109432 A1	10-06-2004
WO 9844754	A	08-10-1998	FI 971328 A	28-09-1998
			AT 274780 T	15-09-2004
			AU 735038 B2	28-06-2001
			AU 6502398 A	22-10-1998
			CN 1109477 B	21-05-2003
			DE 69825878 D1	30-09-2004
			EP 0972417 A2	19-01-2000
			WO 9844754 A2	08-10-1998
			JP 2001516541 T	25-09-2001
			NO 994672 A	24-09-1999
			US 6259685 B1	10-07-2001
WO 9517048	A	22-06-1995	IL 108056 A	15-07-1998
			CA 2156071 A1	22-06-1995
			EP 0685128 A1	06-12-1995
			JP 8509111 T	24-09-1996
			WO 9517048 A1	22-06-1995
			US 5838673 A	17-11-1998
US 2003123425	A1	03-07-2003	US 6493331 B1	10-12-2002
			AU 4937901 A	15-10-2001
			BR 0109639 A	24-06-2003
			CA 2404055 A1	11-10-2001
			CN 1432221 T	23-07-2003
			EP 1269654 A2	02-01-2003
			JP 2003530009 T	07-10-2003
			NO 20024635 A	22-11-2002
			TW 512602 B	01-12-2002
			WO 0176098 A2	11-10-2001

EP 04 29 1152

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82